THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FOURTH SERIES.]

"................. per litora spargite muscum,
Naiades, et circùm vitreos considite fontes:
Pollice virgineo teneros hìc carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

No. 91. JULY 1875.

I.—*Notes Introductory to the Study and Classification of the* SPONGIDA. By H. J. CARTER, F.R.S. &c.

Part I. ANATOMY AND PHYSIOLOGY.

[Plate III.]

Prefatory Remarks.

IN prefacing these "Notes" with a few observations, the first thing that occurs to me, as a spongologist, is that I have lost my lexicographer by the death of the late Dr. J. E. Gray, of the British Museum. With him perished my lexicon, my aider and abettor in the study—in short, my kind and dear friend, whose heart overflowed with humanity, and whose imperishable works testify to one of the most active and sagacious intellects that ever existed. Alas! how little consolation is there in this statement!

These "Notes" will be divided into Three Parts, the contents of which will be respectively as follows:—

1. The Anatomy and Physiology of the Spongida.
2. A proposed Classification of the Spongida into Orders, Suborders, and Families.

3. A further Division into Subfamilies, Genera, and Species so far as our knowledge extends; to which will be added a short commentary.

As regards the First Part, this is almost entirely abridged from my own observations, which have been long since published in the pages of the 'Annals' *in extenso*; hence my former papers will be constantly referred to, for supplying more extended and more satisfactory information than can be embodied in an introduction.

The Second and Third Parts rest chiefly on my study and arrangement of the general and private collections at the British Museum, where *every* specimen has been microscopically examined and the microscopical elements delineated, and will include in addition rough sketches and preliminary descriptions of the most typical and striking specimens, together with the register-number of the specimen and my own private running number, which has also been attached. This of course has been a work of patience and time rather than one of difficulty; but it has led to a general acquaintance with the Spongida which could not otherwise have been obtained, at the same time that it has enabled me to make the classification given hereafter, which I found absolutely necessary before I could put the general collection at the British Museum into any kind of order that might be practically useful.

In my General Arrangement, so far as orders and suborders are concerned the way to me was clear; but I cannot say so much for the families, and still less for the subfamilies, genera, and species, which require a far wider range of specimens in much better condition than those which I have had at my command, although probably the largest and finest collection in the world. Still, from what is hereafter stated, it will be seen that we may have to wait so long for the latter that it is desirable to begin with what we possess, correcting the errors as more and better specimens are accumulated, since the characters which I have assigned as the limit to a group to-day appear to be often upset by a new specimen examined on the morrow; hence the late Dr. Gray was wont to observe respecting the Spongida, that "an accurately illustrated description of a species is the best contribution that can be made to the subject in its present state."

Our knowledge of the Spongida is altogether in its infancy; and hence I have called my observations "Notes," viewing them only as preparatory to what hereafter may become entitled to a more comprehensive term—at the same time seeing that it is necessary to make a *beginning*!

Again, as regards arrangement, I have availed myself, according to my need, of what others have done before me, just as the devotees of one religion that follows another not only make use of parts of the ritual of the foregoing religion, but also the material of its edifices to aid in promulgating their views, without acknowledging either one or the other. At least, such may be seen in the East; and the policy of this course is evident and permissible if the means are justified by the end. There is, however, this difference, viz. that I do not omit the acknowledgment from want of inclination, but from want of time and to avoid confusing the reader.

Further, it should be remembered that this *proposed* Classification is not to be viewed as a dictionary in which a small amount of preliminary knowledge is required to serve its purpose, nor as a classification that has been undergoing revision for centuries. Every one knows that a mariner almost always waits for a pilot to steer his vessel into port; and so it is with classifications. A general knowledge may enable the student to master the larger divisions, but when he arrives at the smaller ones a much more intimate acquaintance is required to guide him to the object he may wish to obtain. There is no "royal road," as it is termed, to this; and if, for instance, in an old and continually revised botanical classification this is necessary, how much more so is it in a classification of which there is only an attempt to lay the foundation.

Lastly, the subject is actually repulsive from its difficulties (as will be seen hereafter); but one who is determined never takes this into consideration: in short, as an old friend used to say to me, "When you are tired, then is the time to exert yourself if you wish to get beyond others; for this is the point where most people stop, and it is astonishing how little further will then place you at the head of the poll,"—which is but

"Tu ne cede malis, sed contra audentior ito."

SPONGIDA.

The term "sponge" is so generally accepted and of such great antiquity that it needs no excuse for preference; but as there are many kinds of sponges which more or less differ from that to which the term "sponge" is commonly applied, it is necessary to add some terminal affix by means of which all kinds may be added under the same name. Thus, if from the Greek word σπόγγος (sponge) we form a patronymic in the neuter plural, we get "Spongida," which, meaning "*Zoa Spongida*" (for the animality of sponges is now established), seems to me the best form that can be adopted for this purpose.

It may be said to be not so applicable as the term "Porifera," which has also been used for sponges; but in the promulgation of knowledge of whatever kind, as well as of opinion, it is an established principle not to scare away by new names and new things, but to retain as much as possible of the old, that the human mind may be tempted to receive that which under an unaccustomed appearance it might reject. Thus many a good system has never been generally adopted, because it has involved an entirely new nomenclature.

A sponge, in the common acceptation of the word, is the fibrous portion or skeleton of a pulp-like mass, and is analogous to the fibrous skeleton or support of a vegetable whose pulpy or soft parts have been washed or rotted away by putrefaction (*ex. gr.* hemp); only, in the first instance the fibre is horny (that is, of an animal), and in the latter woody (or of a vegetable nature). The skeleton of the sponge of commerce is resilient; but that of many Spongida is not so; and there are some in which it is glass-like and rigid; while in others it is altogether wanting, there being apparently no skeleton at all, and the whole mass, with the exception of the dendriform plexus of the excretory canal-system, is a simple pulp.

Sponges grow only under water and in the sea, all over the world (that is, as far as our geographical discoveries have extended), in the torrid as well as in the frigid zones; but as with plants and animals, so with sponges, particular ones are only to be found in particular localities. Thus the sponge of commerce is chiefly obtained from the Levant &c.

Again, they grow on hard bodies, such as rocks, or on soft ground, such as sand or mud: the rocks may be in deep or in shallow water; and so may be the soft ground. When growing on rocks, they for the most part fix themselves by flat expansion or root-like extension to the upper or under surface; and when on sandy or muddy ground, by root-like extensions alone projected into the sand or mud. When growing on the under surface of the rock towards shore or in submarine caverns, they may be pendent; and this is their wonted position and chief habitat; but when on the ground or on the surface of the rock, they are of course erect. Although for the most part preferring fixed objects, some kinds are found growing over shells which, from their kind, never could have been stationary; and some on the fronds of Fuci, which never could have been still, but ever waving in the Laminarian zone.

Again, some sponges grow both on the under and upper surfaces of rocks respectively of this zone, others in similar positions further out in the shallow seas, and others similarly situated in the deep seas. None of these in such positions, therefore, can be obtained by the dredge; and it is only when growing in such parts of the Laminarian zone that, as the tide leaves them uncovered, they can be obtained by the hand, unless gathered by divers from the rocks of the shallower seas, who then restrict themselves to such species as are likely to meet with a general and not a particular sale in commerce. Those alone which grow on the ground can be scraped off by the dredge or such like means; and the rest, if not obtained directly by the hand, come to us accidentally from the parts where they grew. The latter are for the most part broken off from their place of growth in deep water by having become "heady," or too heavy to be held on by the root, or by violent storms when growing on rocks in shallow water, after which, in either instance, they may be carried about in the sea by currents for a longer or shorter time, until they are finally thrown upon the shore by the waves, wherein they become more or less injured by trituration. After stranding on the beach they may be picked up at once and preserved—or they may be drawn into the sea again and again, and thus washed along the beach as the wind changes, up and down, backwards and forwards, buried and unburied in the sand and pebbles repeatedly, even for years, until they come into the possession of the collector. In the first instance more or less of the flesh or soft parts may remain upon them; but in the second, of course, nothing will be left but the skeleton; and in this state, for the most part, they at last find their way into our museums, picked up, perhaps, on some Survey by one.

> "Who loves to roam along the shore,
> Where none have ever walked before."

Hence it may be easily conceived that, such specimens being analogous to a deciduous tree in winter, no further description of them can be given than that which the bare skeleton permits. Again, as it is in the deeper water (from its stillness), and for the most part probably in submarine rock-caverns, pendent from the roof or projecting from the sides, that sponges attain their largest dimensions, so the larger specimens in our museums may be assumed to have come chiefly from these localities, and in the way and state above mentioned. At the same time, it should be remembered that there are several "land-locked" places where the sea is ever more or less calm; and therefore the same stillness which exists at great depths, and is so favourable to large growth, may be found in comparatively shallow water.

Notwithstanding all this, the Laminarian zone of our coasts, which is being beaten upon almost unremittingly by boisterous waves, frequently in the most tempestuous weather, is crowded with various species of Spongida, but all more or less dwarfed from such exposure.

Besides marine there are also freshwater sponges; and these grow in tanks, lakes, and rivers, on rocks, branches and roots of trees, and aquatic vegetation generally, where they may be subject to be left uncovered and dry for several months of the year.

Forms that may be assumed by Sponges.

The forms that may be assumed by sponges are very numerous and very different, not only in the mass, but in the individual; since, although a species may be recognized by the form which it generally assumes, yet it may assume other forms so different that it would be hazardous to decide on this alone. Still the old practice in the description of a sponge was to deal with the form only; nor can we do without it now; but the addition of the elementary composition, which came in with the improvements of the microscope, has furnished us with the means of correcting the mistakes to which this was liable. Yet the absence in the Spongida of any expression visible to the naked eye, as the flower on a plant or the calice on a coral, will ever be commensurately disadvantageous in the description of sponges. Indeed, as will be seen hereafter, little is to be achieved without the aid of the microscope, since, as before stated, the same species may assume different forms, and unfortunately the same elementary composition may also be accompanied by different forms, while, there being certain classes of forms which appear to be evolved out of each other, two species may assume the same form and therefore at last be only determinable by the microscope.

All this shows that the form of sponges is not less Protean than their soft parts will hereafter be found to be; and hence their study presents difficulties in the way of classification and species-determination to which no other branch of natural history is equally subject.

As, however, the means of designating sponges was originally and necessarily restricted to their forms and the likenesses they bore to some well-known objects, this means obtained considerable development; so that the following Table, although a little differently arranged, presents very little new in this way, and is intended to supply the student with the means not only of determining, but of describing a sponge so far as its general form may be concerned.

(For private use I also possess the accompanying Table of delineations corresponding to the names in the text: Plate III.)

Table of Forms that may be assumed by Sponges.

I. *Massive sessile, or spreading horizontally.*

a. Simple.
b. Lobed.

II. *Subpediculated or contracted at the base.*

a. Simple. *b.* Lobed.	Massive or compressed.

III. *Masses branched.*

a. Simple. *b.* Lobed. *c.* Dendritic. *d.* Anastomosing.	Solid or Tubular or Compressed. Sessile or Stipitate.	Vertical or Horizontal.

IV. *Flat or Fan-shaped vertically or horizontally.*

a. Palmate. *b.* Lobed. *c.* Simple. *d.* Patella-like.	Massive or Compressed. Sessile or Stipitate.	Single or *e.* Grouped or *f.* Branched proliferously.

V. *Hollow.*

a. Crateriform. *b.* Vasiform. *c.* Funnel-shaped. *d.* Trumpet-shaped. *e.* Tubular. *f.* Obconic.	Circular or Oval or Compressed. Sessile or Stipitate.	Single or Grouped or Proliferous.

VI. *Masses foliated.*

a. Simple. *b.* Lobed. *c.* Plicate.	Compressed or Eccentric or Concentric or Rose-like. Sessile or Stipitate.	*d.* Proliferous.

Observations.

Although the above Table includes most of the forms assumed by sponges, still it must not be inferred that it contains all; hence the student can add others to it at discretion.

Again, the same species, as above stated, may have several forms. Thus the massive form of a species may rise into a bunch of digital processes; these may again become branched into a tree-like or globular head, after which the branches may unite laterally or by their ends anastomosingly. Or the digital processes may be all on the same plane, simple or branched, &c.; they might then coalesce partially, so as to present a fenestrated or clathrous form, or, being single and straight, might unite laterally throughout so as to assume a fan-shape. After which the fan-shape has a tendency to assume a conchoidal form (like that of a clam-shell) and finally, becoming more and more concave, to meet on each side, join up, and thus form a vase, in which there is often a hole at the bottom from the union not being complete.

In this way a simple may pass into a complicated form, and thus many different forms be produced from evolution (see "Beitrag zur Morphologie und Verbreitung der Spongien," von N. Miklucho-Maclay, Mém. Acad. Imp. des Sci. St. Pétersb. 1870, t. xv. no. 3, Taf. 1).

Composition of Sponges.

Skeleton generally.

The general structure of the skeleton is reticular; and this may be compact or open, tough or tender; but under this state it may assume any of the forms above mentioned, each of which is not always an indication of a particular species; for in many instances the same species may assume several different forms, as has just been shown.

Minute Structure of the Skeleton.

The element of which the skeleton is composed may be termed "fibre;" and this is of two sizes, viz. large and small. The large fibre is the oldest, and generally grows vertically or in a direction more or less radiating from the base, in accordance with the general form of the sponge; while the smaller fibre, which is the younger of the two, unites the large fibres obliquely or transversely. In the skeleton of some species there is such a uniformity of growth that no lines of large fibre can be distinguished; and thus a simple reticulation goes on from the base to the circumference, presenting a simple gradation in size from the oldest to the latest-formed portions.

The fibre may be glass-like, horny, or spiculous—that is (in the latter case), composed almost entirely of spicules bound together by a minimum of sarcode.

(Spicules are siliceous or calcareous bodies, according to the nature of the sponge, which are developed by the sponge itself, and vary greatly in form, being for the most part linear and pointed at each end, as will be more particularly described hereafter.)

Again, the glass-like fibre contains a core of spicules; and the horny may be cored with a fine granular substance or with foreign bodies or spicules respectively.

Thus the fibre consists of two distinct parts, viz. the wall and the axis or core.

There is no difficulty in distinguishing between the glass-like and the horny fibre; but there is frequently a difficulty in determining between the horny cored with proper spicules and the spiculous fibre, since the horny substance is composed of the same material as the film which binds together the spicules of the spiculous fibre; and therefore the distinction is only one of degree, viz. that of whether the spicules or the horny substance forms the chief part of the fibre. Still, for the sake of classification, it will be found by-and-by necessary to make the distinction. When horny, the horny matter preponderates; when spiculous, the spicules.

The axis or core, however, is evident in all. Thus in the glass-like fibre it consists of proper spicules ("proper spicules" are spicules that are formed by, and peculiar to, the species); while in the horny fibre the core may consist of a fine, uniformly granular, tubular membrane or sheath everywhere anastomosing and the same, or of foreign objects which, in some parts, may be so scanty that the fibre for the most part is horny throughout; or the core of foreign objects may be so general as to form the axis in *every* part of the fibre, so that there are many degrees between these two extremes; or the core may consist of foreign objects and "proper spicules" mixed together, or of proper spicules alone. Lastly, as before stated, in the spiculous fibre not only the axis, but the whole fibre is composed of "proper spicules" held together by a minimum of hardened sarcode, which from its thinness is almost imperceptible, while the fibre thus composed is, when dry, opaque and white.

In addition to the core, the fibre is sometimes *echinated* with "proper spicules"; that is, the latter have only one end fixed in the surface of the fibre, or otherwise, being *in* the core, project through the fibre to a considerable extent. Thus the core of the fibre may consist of one form of "proper spicules" and the echination of another; or the form of the spicule a little modified may be the same in both; or the core may consist of foreign objects together with an echination of "proper spicules," as before stated.

Finally, the core may be generally or partially continuous (that is, interrupted).

Extremities of the Fibre.

The basal or radical ends of the fibre are of course fixed to the rock or other hard object on which the sponge may be growing, or projected into the sand or mud at the bottom of the sea, as the case may be; so that it is with the circumferential ones that we are now chiefly concerned.

The circumferential ends may terminate in simple anastomosis on a level with the surface; or the larger fibre may project in attenuated tag-like conical ends permeated respectively by a single horny hair-like filament, or filled with an axis of foreign bodies and surrounded by a dense anastomosis of simple small fibre, which, branching off into a more open reticulation at the circumference or base of the cone, joins that of the neighbouring tags. Or the tags may present themselves in the form of spines filled with an axis of "proper spicules" instead of foreign bodies — or in the form of monticules cored with one or more large spicules, which thus form the axis, and project a considerable distance beyond the summit like a hair or bunch of hairs. Or the large fibre may end in a dermal reticulation which may be surmounted by naked tufts of "proper spicules" that, when large, come into contact with each other and thus form a continuous incrustation more or less densely hirsute.

Such are the usual modes of termination; but of course they are subject to great modification.

Sponges with no Skeleton.

In some sponges, as before stated, there is no fibrous skeleton, and no apparent agent of support beyond the dendriform canal-system and the spicules; while in others there is not only no fibre, but also no spicules, nothing but the sarcode and the dendriform canal-plexus.

Nature of the Foreign Bodies.

The "foreign bodies" of the core chiefly consist of grains of sand mixed more or less with siliceous and calcareous spicules of other sponges (entire or fragmentary), of the spicules and calcareous structures of Echinodermata, of Diatomaceæ, and of minute Foraminifera—indeed, any thing of this kind, especially calcite in a minute columnar or prismatic form, banded with hair-brown, yellow, and amethystine colours, originally derived from the disintegration of thin bivalve shells allied to *Pinna*. At first I was at a loss to account for the origin of these little prisms; but finding them in certain kinds of sponges from all quarters of the world, especially from Port Jackson in Australia, and at last in direct connexion with some specimens of *Crenula phasianoptera* which had been overgrown and enclosed bodily by the sponge itself, their general occurrence, rhombohedral prismatic form, and banded colours were thus explained.

Spicules.

The spicules, as their name implies, are pointed, siliceous or calcareous bodies produced by the sponge itself, of an infinite number of forms, varying in accordance with the species, and extending from a simple linear one, pointed at each end, to the most complicated figure.

At first it would appear that the spicule is produced in the homogeneous or intercellular sarcode (that is, the basis or original living slime in which every part of the sponge is developed and imbedded), as it is present and of such a large size comparatively in the ovum even before the latter becomes elongated into the embryonal form, as well as in the intercellular sarcode of the adult sponge, that in either case there is no cell approximately large enough to contain it. But since, in some instances, it can be followed during part of its development (that is, from the time it is first recognizable to that in which it is considerably enlarged), while still within the parent or mother cell ('Annals,' 1874, vol. xiv. p. 97, pl. x), it may be assumed that all spicules are initiated in a mother cell, however soon after they may get into the intercellular sarcode. Thus the spicule appears to arise, within a mother cell, from a granule which, for convenience, will be termed the "spicule-cell," which cell becomes extended linearly in opposite directions, or immediately begins to put forth more or less points in a radiating direction, whereby what is called the central canal of the spicule is formed; and upon the tubular prolongations as they extend is deposited, in concentric layers, the siliceo- or calcareo-albuminous material of which the spicule may be composed, the extremity of the tubule or central canal only becoming covered when the fundamental form of the spicule is completed. Hence the spicule always has a central canal, which remains hollow in the siliceous ones, but in the calcareous spicules appears to me to be filled up by the same material of which the spicule itself is composed; while in some large, robust, acerate siliceous spicules, too, it is often diminished to an almost imperceptible line in the centre, although comparatively wide towards the extremities—thus showing, in some instances, a tendency to become filled up in the same way as the calcareous spicules.

That the spicule is developed from a central cell is often confirmed by the presence in some sponges of more or less abortive attempts at elongation, whereby globular or elliptical bodies of considerable size are formed through the deposit of concentric or successive layers of siliceo-albuminous material upon a central or elongated cell as the case may be, which for some reason has remained stationary, although it has continued to develop successively the layers of which the normal linear form is composed.

When once the spicule can be recognized, it is not difficult to follow its further development, which goes on *pari passu* with the extension of the central canal, linearly or in a radiating manner, as before noticed. If the spicule has a decided linear shaft, this makes its appearance first, and the radiating branches appear afterwards at one of its extremities; so that the *primary* form of a shafted spicule would always be a straight line. At least this is what may be seen among the spicules in the ovum of *Tethya cranium* ('Annals,' 1872, vol. ix. p. 429, pl. xxii. fig. 16). But while the central canal goes on extending itself as the spicule grows larger, it never goes beyond what may be termed the *fundamental form* of the spicule, which is thus determined by the central canal. All ornamental or subsidiary parts, such as the spines &c., are subsequently added, probably after the spicule has left the mother cell and has got into the intercellular sarcode, as shown by the central canal never extending into them. But still it may be a question whether they are not all *initiated* by the central canal, and thus appear to be evolved like any other development which cannot be traced backwards beyond a certain point.

We shall find by-and-by that, besides the spicules especially belonging to the skeleton, there are others as especially belonging to the sarcode or the soft parts, which will be described in connexion with this portion of the sponge-structure, to which they are so intimately attached that, when the sarcode drops off the skeleton from putrefaction, they for the most part go with it—thus still further reducing our means of describing the entire sponge from the skeleton alone.

As the *known* forms of the skeleton-spicules of sponges are exceedingly numerous, it may fairly be inferred that with the discovery of new species of sponges these forms will be found to be almost infinite. At the same time, as they are of much consequence in specific distinction, it becomes necessary to adopt some classification of them whereby the memory may not only be aided in this respect, but assistance may also be given in describing new ones.

Under these circumstances I have framed the following Table, in which the known forms of the skeleton-spicule are divided into three groups, viz. linear, radiating, and ramular, each of which is based upon a fundamental form out of which its divisions, subdivisions, genera, and species may be evolved. The fundamental forms will be found in the woodcuts; and their modifications, in accordance with the text, will be delineated hereafter in separate Plates, when the species are noticed to which they respectively belong.

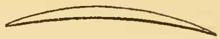
It has been already stated that the development of the spicule commences in a granule or minute cell, which on elongating would give the "linear group," or on immediately radiating would give the "radiating group," or, by elongating first and then branching off radiatingly at one or both ends, as the case might be, would give the "ramular group." Thus the Table of Forms would be based not on mere artificial arrangement, but absolutely on the development of the spicule. That it should be viewed as complete even up to the forms with which we are already acquainted is by no means wished; but that provisionally it offers a beginning to what must in this respect be ultimately accomplished is all that can be expected.

My kind friend the late Dr. J. E. Gray being well aware of the importance of this subject in studying the Spongida, communicated a valuable paper upon it ('Annals,' 1873, vol. xii. p. 203), to which the reader is referred for the views he has therein enunciated.

Table of known Forms which may be assumed by the Skeleton-Spicule of the Sponge.

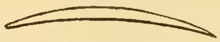
I. Linear Group.

Acerate.



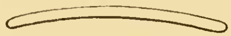
Simple Acerate, viz. linear curved, smooth, fusiform, pointed at each end.

Fusiform.



With or without central inflation.

Cylindrical.



Uniform in calibre throughout.

Curved, straight, spirally sinuous or multiangulate.

Pointed at each end gradually, abruptly, or hastately. | Obtuse or rounded at each end.

Inflated at each end.

Smooth or spined.

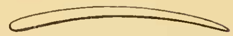
Spines conical or obtuse.

Vertical, inclined or recurved.

Spined throughout, mesially or terminally, more or less.

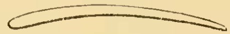
Spines scattered irregularly or verticillate.

Acuate.

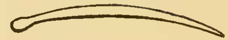


Simple Acuate, viz. linear, curved, smooth conical, round at one, pointed at the other end.

Conical.



Fusiform.



Curved, straight, or sinuous.

Pointed gradually, abruptly or obtusely.

Obtuse end round or inflated.

Inflation larger or smaller in diameter than the shaft.

In a line with the shaft or bent to one side.

Inflated, globular, ellipsoid or bulb-like.

Terminal or subterminal.

Smooth or spined.

Inflation single or double.

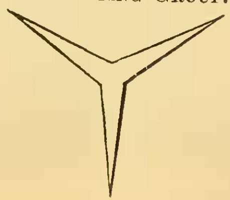
Spines conical or obtuse.

Vertical inclined or recurved.

Spined throughout, mesially or terminally, more or less.

Spines scattered irregularly or verticillate.

II. Radiating Group.



Three-rayed, four-rayed, five- or six-rayed. Rays smooth, conical.

Straight or curved. Opposite or inopposite.

Equal or unequal in length.

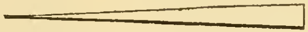
Pointed, obtuse, inflated or bifid at the ends.

Spined generally or only at the ends.

Spines vertical, or inclined outwards or inwards.

III. Ramular Group.

Shaft.



Terminating in the head, or prolonged beyond it.
Very thin, medium size, or robust.
Very long, medium size, or short.
Attenuately or abruptly pointed.
Smooth, or spined partially or entirely.
Spines distinct or indistinct, vertically extended or recurved.
Dividing into branches simple or subdivided, at one or both ends: branches smooth or tubercled, filigreed curvilinearly, and interlocking with those of the subjacent layers. See "*Head.*"

Head.

Three-armed, four-armed, or multiarmed.
Arms expanded horizontally, obliquely, or anteriorly fork-like; or recurved anchor-like.
Conical.
Straight, round, or sinuous.
Opposite or inopposite.
Equal or unequal in length.
One, two, or three dichotomously divided.
Branches smooth or spined.
Spines distinct or indistinct, vertical, extended or recurved.
Branches or arms uniting into a simple circular disk, with even curvilinear margin more or less indented.
Arms and branches flattened and sinuous with even margin, or flattened with denticulated margin.
Arms and branches more or less round, infinitely and irregularly divided, spino-tubercled on one or both aspects (outer and inner), filigreed.

Anchoring-Spicules of the Hexactinellida.

Shaft.

Immensely long, fusiform.
Smooth or spined sinuously and subspirally.
Spines on the projections of the spire single or in groups confined to the lowermost third more or less.
Spines conical, smooth, directed towards the sponge.

Arms.

Arms short, recurved, anchor-like, conical, smooth, round, or compressed laterally.
Two, four, or more, opposite, inopposite, or lateral.
Rising from a tumid head, or with no perceptible inflation at this point.

Position of Surface-Spicules.

Where a spicule which has a point projects beyond the surface of the sponge to which it belongs, that point will be always outermost; but, of course, where both ends of the spicule are equally obtuse or bulb-like, an obtuse end *must* be outermost.

Still, as sponges are wont to seize with their sarcode any minute object that may impinge upon their surface, it is possible that, if this be a pointed spicule with one obtuse end, the latter may be outermost. But here the spicule does not belong to the sponge, it is a foreign object; and thus it becomes very desirable to distinguish between such foreign objects and the "proper spicules" of the sponge, so that the former in the description of the species may not be set down as part of the spicule-complement.

Monstrosities.

Again, spicules are much subject to monstrosity; and therefore it is very desirable to find out the *staple* form first, and describe or figure this, after which the others may be figured as *monstrosities.*

Development of the Fibre.

Although the fibre appears to originate in a cell which puts forth buds or processes ('Annals,' 1872, vol. x. p. 107, pl. vii. fig. 5, *c*, *d*, *e*) in plurality, and these in juxtaposition may, by elongation and anastomosis, produce a uniformly reticulate structure whose simple tubular core may be continuous and without foreign objects, like the "fine, uniformly granular" one above mentioned, still the final enlargement of the fibre by concentric layers throughout its whole course must be derived from the intercellular sarcode in which it is imbedded, just as in that of the spicule, whose substance being siliceo-albuminous renders the process identical with the formation of the glass-like fibre.

But although the extension of the fibre and the spicule respectively may be produced by a linear bud-like growth of the original cell in the first instance, these cells do not appear to me to be afterwards identified by their products, as Fritz Müller and others have fancied from the corneo-stellate form of the fibre in *Darwinella aurea* = *Aplysina corneostellata* (see 'Annals,' 1872, vol. x. *l. c. anteà*). Each structure has its peculiar origin and product distinct from the other.

So far we can understand the formation of the "simple fibre" *without* foreign bodies in the core; but when we find fibre cored with foreign objects or "proper spicules," we have to assume that the original germ, which for convenience we will term "horn-cell" (in accordance with what has already been stated of the horn-cell in the Hydractiniadæ, whose functions are analogous, 'Annals,' 1873, vol. xi. p. 6, pl. i. fig. 7), is at first living and plastic, when, *amœba*-like, it may take in foreign bodies, and, having arranged them in a linear or branched form, then proceed in the way mentioned to anastomose with the branches of other similar horn-cells, and thus finally produce a reticulated structure with a core of foreign objects as continuously throughout its whole course as the "fine granular tube" in the fibre without foreign objects, subsequently in like manner receiving, concentrically, additional layers from the intercellular sarcode of the sponge.

There is much more to commend this theory to our notice in the microscopical examination of the fully developed fibre itself, which need not be mentioned here; at the same time, it is impossible to conceive how foreign objects or "proper spicules" can become the core of horny fibre unless by some such hypothesis as that above stated.

Having thus described the spicules and the fibre of the Spongida, it is desirable to notice here that as there are sponges which only possess siliceous spicules, these will be termed "Siliceous Sponges," while others which only possess calcareous spicules will be termed "Calcareous Sponges."

Again, as the fibre may be either glass-like with proper spicules, or horny alone, or horny with foreign bodies, or horny with proper spicules, or composed of spicules only, the terms "vitreous," "horny," "arenaceo-horny," "spiculo-horny," and "spiculo-fibre" will be used for these kinds respectively; while there is yet another modification, as before stated, in which the core may consist of foreign bodies and proper spicules mixed.

Dissolution of Fibre and Spicules.

I have already noticed the disappearance by wasting or decay both in the siliceous and calcareous spicules, together with that of the glassy fibre ('Annals,' 1873, vol. xii. p. 456 *et seq.*); but I omitted to notice that the "proper spicules" of the spiculo-horny fibre also disappear after the same manner, leaving nothing in many instances but their central canals, with a fragment perhaps of the entire shaft in some part of their course, frequently in the middle (thus looking like a cotton-reel upon long spindles), which at first appeared to me like a new form of spicule; hence I mention the fact. The horny sheath or part of the fibre remains; but the spicules of the core almost entirely disappear.

Sarcode.

The sarcode of sponges may be generally defined to be the pulp-like part in which all the rest of the structures are not only imbedded, but from the original slime of which all have been developed, and is analogous to the soft parts of other beings, filling up the insterstices of and enclosing the skeleton or organ of support, thus giving more or less roundness to the surface of the whole mass. But as it is for the most part extremely delicate in structure, the cessation of life almost renders it semifluid, whereby it runs off the skeleton in some cases like oil. Being, too, of an albuminous nature, it collapses like glue when dried upon the skeleton in its fresh state, or coagulates upon it when placed in spirit. Both are preservative means in which the altered sarcode, so long as it is kept from putrefying (when it becomes exposed to the ravages of fungi), will last as long as the horny parts of the skeleton; but of course, on drying, its structure is greatly obliterated, although not so much so when coagulated and contracted by the astringency of spirit.

Tender and delicate, however, as the structure of the sarcode and its soft contents are, especially in the calcareous sponges (where there is no horny fibre, and therefore nothing to hold the spicules together but the living sarcode), we may observe the calcareous sponges growing upon the under surface of rocks on the sea-shore to increase in size and develop their forms there in the midst of daily washing by the falling and rising of the tides, to say nothing of the accompanying waves which are often rendered more or less boisterous by the wind; while if *life* were to be abstracted for an instant they would go to pieces immediately, just as "diffluence" takes place in animalcules under similar circumstances, or as a bunch of iron-filings kept together by a galvano-magnetic current falls to pieces when the circle is broken. Such is the power of *life* in keeping together the particles of which these living structures (which crumble to pieces under the finger and thumb when dry) are composed!

In using the term "sarcode" for the pulp-like part of sponges generally, it must be understood to imply that it is compounded of many parts, each of which requires a particular description.

Thus, when we come to examine the sarcodic mass microscopically, we shall find that its base is composed of a granuliferous, almost transparent, living substance like jelly. It is this living, locomotive, apparently structureless substance, to which I have before alluded, which holds all the rest together, and, originating in its simplest form in the ovum, as will be shown hereafter, finally evolves all that is subsequently developed in the sponge.

Of its *living* nature we, of course, can have no idea except from its manifestations; and of these I can offer no better description than I gave in the 'Annals' for 1849, vol. iv. (pp. 87 & 91, pl. iv. fig. 2), in the following passage, which will be found at p. 91:—

"If a seed-like body [of *Spongilla*] which has arrived at maturity be placed in water, a white substance will, after a few days, be observed to have issued from its interior through the infundibular depression on its surface, and to have glued it to the glass; and if this be examined with the microscope, its circumference will be found to consist of a semitransparent substance, the extreme border of which is extended into digital or tentacular prolongations, precisely similar to those of the Protean, which in progression or polymorphism throws out parts of its body in this way (pl. iv. fig. 2, *c*). In this semitransparent substance may be observed hyaline vesicles of different sizes, contracting and dilating themselves as in the Protean (fig. 2, *d*); and a little within it the green granules, [germs] so grouped together (fig. 2, *e*) as almost to enable the practised eye to distinguish *in situ* the passing forms of the cells ["spherical cells" of the seed-like body] to which they belong. We may also see in the latter [these "cells"] *their* hyaline vesicles with their contained molecules in great commotion, and between the cells themselves the intercellular mucilage (fig. 2, *f*)." The "intercellular mucilage" is the "semitransparent substance" above noticed, and for which I have above used the term "intercellular sarcode."

For another description of the "intercellular mucilage" see p. 87 of 'Annals' (*l. c.*). Thus in 1849 attention was directed to this primordial plasma.

The sarcode proper (for thus the "intercellular mucilage" might be designated) envelops the whole of the fibre, and, filling up the interstitial spaces of the skeleton, forms an areolar structure, which is densely charged with the "ampullaceous sacs," the "ova of the sponge," "muscular cells," together with various other kinds of cells not yet described if even recognized, and the "flesh-spicules;" while the mass generally is traversed by the inhalant and exhalant or excretory tubular branched systems—the former descending from the "pores" on the dermal surface *to* the ampullaceous sacs, and the latter leading *from* the ampullaceous sacs in little radicles, which uniting and interuniting at length form a large canal that opens on the dermal surface in the "vent."

Hence we shall have to examine each of these parts in particular, and thus pass from the general to the minute structure of the sarcode, in doing which it will be advantageous to divide the latter into that of the surface and that of the interior—the former under the term of "dermis," and the latter under that of the "body."

Dermis.

The dermal surface of sponges varies with the species: it may be uniformly smooth, or uniformly irregular, or uniformly hispid, aculeated, and even prickly, soft or hard; while in composition it may be sarcodic, horny, spiculous, or sabellous; but the chief points to remember are that the dermal sarcode or cuticle is supported for the most part by a subjacent reticular structure or framework, composed of one or more of these constituents, in the interstices of which the *pores* are situated, and here and there the *vents*, scattered singly or in groups.

This reticular framework when soft is formed of anastomosing fibre composed of elongated, spindle-shaped, granuliferous, nucleated, gelatinous cells, which lie parallel to each other (the "muscular cells" to which I have alluded, and which will be more particularly described hereafter)—or of simple horny fibre—or of horny fibre with a core of foreign bodies (the so-called arenaceous fibre)—or of horny fibre with a core of "proper spicules" (spiculo-horny fibre)—or of fibre composed almost of proper spicules alone (spiculo-fibre)—or of arenaceous fibre bearing foreign bodies on its outer surface as well as internally—or of spiculo-horny fibre or spiculo-fibre bearing respectively tufts of proper spicules on its external surface, so as to present a hirsute appearance, or with the same tufts so enlarged as to come into contact and thus to form a continuous incrustation; or, indeed, there may be no fibre at all but a smooth membraniform envelope composed of horny sarcode imbedding spicules of the species horizontally placed with respect to each other like a textile fabric, as on many of the deep-sea sponges dredged up on board H.M.S. 'Porcupine,' but always leaving apertures for the pores and vents respectively.

The "reticular framework," again, is supported on, if not given off from, the dermal extremities of the main or vertical lines of fibre of the skeleton, which may terminate at once on a level with the surface by simply anastomosing with each other through the intervention of the reticular framework of the dermis—or in an intricate reticulated structure with a core of foreign objects, which projects in a conical form beyond the surface—or in the same way, with a core of proper spicules assuming the form of an aculeation. These aculeations, again, may be separate or connected by prominent lines of fibre passing directly between them, which, bearing respectively a fold of the dermal sarcode, thus give a polygonally divided cellular aspect to the surface. Or the aculeation may be rounded by the projection of tufts of proper spicules based *upon* the reticulated fibre of the dermis. Indeed the aculeation always partakes of, and is modified in form by, the nature and composition of the dermal reticular framework.

Again, it should be remembered that, although these parts may be frequently bare (that is, uncovered by sarcode) in the fresh as well as in the dry specimen, they were originally invested by it, and only became denuded through wear and tear or natural withdrawal of the sarcode.

Body.

Having already described the skeleton and the sarcode *generally*, together with the "sarcode proper" or intercellular substance, as the basis in which all the other structures are imbedded and, as before stated, out of which they are all elaborated, also having described the "dermis," we shall now direct our attention to those parts of the sarcode of the body which have hitherto only been enumerated, beginning with the

Ampullaceous Sacs.

When the sponge is fed with carmine or indigo, which of course can only be effected during its *active living* state, the colouring-matter with the water is drawn into the substance of the sponge through the *pores* in the dermis, when also the former becomes arrested on the surface of the areolar cavities of the sponge, at points which present a globular or sac-like rounded form. To these points I have heretofore given the name of "ampullaceous sacs," because I found them in *Spongilla* (where I first saw them) of a globular form with a distinct sphinctral opening. They are exceedingly numerous, and may be said, comparing small things with great, to hang about the branches of the excretory canals like grapes in a bunch of this fruit.

The aperture in this assumed sac (for the sarcode, which is probably of the "intercellular" kind, is too subtle to present a distinct cell-wall) is circular and evidently sphinctral, inasmuch as it has the power of dilating and contracting itself, while, by adjusting the focus of the microscope to the interior, when the aperture is open, *in situ*, *under water*, and in an active living condition, cilia may be observed in a state of undular vibration.

Thus, watching the particles of carmine as they pass from the water through the *pores*, they appear to reach the interior of the ampullaceous sac through the opening just described. And still keeping our eye on the sac, we may observe that, after a time, certain of the coloured particles are transferred *en masse* into a circumjacent branch of the excretory canal-system, whence they immediately get into the main trunk, and are ejected at the *vent*; so that it must be assumed (for it has not been demonstrated) that there is a second or excremental aperture in the sac here, as in that of the calcareous sponges, unless the material is extruded into the excretory canal through an extemporized aperture, after the manner of an *Amœba*. The ampullaceous sac in the siliceous sponges is, for the most part, globular, but may be subglobular and sac-like of different shapes. In diameter it is about 1-600th of an inch in the siliceous sponges, and the body of the spongozoon (about to be described) from 1-6000th to 1-3000th of an inch in diameter, both ampullaceous sacs and spongozoa being by far the largest in the calcareous sponges.

Spongozoa.

So far our observation has been limited to what takes place in the ampullaceous sac generally. We have now to see what the organs in the sac are that receive the colouring-matter; and to ascertain this we have only to tear up a portion of the thus coloured sponge with needles, when we shall observe that the particles of carmine are in monociliated conical bodies, which in juxtaposition form a pavement-like structure round the inner surface of the sac, from which their cilia vibrate into its interior. For these bodies singly I have proposed the name of "spongozoon" ('Annals,' 1872, vol. x. p. 45).

Moreover we observe that in the *active* living state, or just after the spongozoon has been scratched out from the body of the sponge (for it soon passes into an amorphous amœboid condition), the spongozoon has a definite form, as the late Prof. James-Clark, of America, first pointed out in the calcareous sponge called *Leucosolenia botryoides*; and in another calcareous sponge, viz. *Grantia compressa*, I find it to consist of a round or conical body, from which projects a long bacilliform tube somewhat inflated at its extremity, where the neck of the inflation is surrounded by a sarcodic frill; and from its summit proceeds a long cilium (altogether not unlike the pistil and corolla of a flower), while in the body may be observed a granuliferous sarcode containing a nuclear organ and one or two "contracting vesicles," which, carrying out the simile, would be analogous to the seed-vessel of the flower.

Fig. 1.

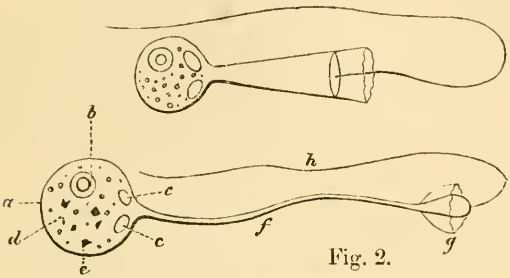


Fig. 2.

Fig. 1. Common form of spongozoon in *Grantia compressa*.
Fig. 2. Not unfrequent form: *a*, body; *b*, nucleus; *c c*, contracting vesicles; *d*, granules of sarcode; *e*, grains of food; *f*, rostrum; *g*, collar; *h*, cilium.

Scale 1-4th to 1-6000th of an inch.

The conical bulb-like portion has been called the "body;" the bacilliform tube, the "rostrum" or beak; the sarcodic frill, the "collar," in the midst of which is the inflated end of the rostrum and the cilium.

This, then, is the form of the spongozoon of *Grantia compressa* in its *active* living state; and that it is the animal of the sponge may be assumed from no other body or cell in the sponge taking in the colouring-matter *.

That the particles of colouring-matter pass into the ampullaceous sac directly through the pore has been demonstrated by the presence of a continuous line of colouring-matter having been seen to exist between the pore on the surface and the ampullaceous sac ('Annals,' 1874, vol. xiii. p. 437); and that subsequently it may pass into the body of the spongozoon through the rostrum or beak (by the side of the cilium, as in such flagellated Infusoria generally) seems most probable,

* It must not be thought that the colouring-matter requires to be so minutely divided as for its particles to be almost imperceptible, since the "rostrum" is so expansible that it will often admit the spores of Algæ into the "body" of the spongozoon, especially at the end of the breeding-season (say June), when the form of the spongozoon generally also appears to be best developed.

although from the polymorphic nature of the body it seems also not impossible that, on impinging upon its surface, it might be *incepted* after the manner of *Amœba*; but from what part of the spongozoon it is *ejected* remains to be discovered.

To describe the organ into which the colouring-matter first passes as a "sac" might appear objectionable, as, in its active living state, there is nothing but the globular form and sphinctral opening to support this view; but if we recur to the contents of the seed-like body (winter-egg or statoblast) of *Spongilla*, it will be found that they consist of a number of "spherical cells" respectively charged with germiniferous bodies, each cell of which with its contents, as the young *Spongilla* grows out of the hiliform opening of the seed-like body, becomes developed into an ampullaceous sac, when the spherical cell ceases to be demonstrable, from the commencement being so subtle in nature that, on placing a portion of the contents of the dried seed-like body in water, it is rapidly distended by imbibition, bursts, and disappears. Thus it may be assumed that there is a subtle film which holds the spongozoa together in the living *Spongilla*, just as the spherical cell contains the germs from which the spongozoa are developed in the seed-like body; and so far we are warranted in using the word "sac." That this cell in the dried seed-like body might pass into a living plastic state is confirmed by the germinating of the rest of the substance itself of the seed-like body, which was equally dry, returning to this state—to say nothing of the entire sponges which, on the walls of the tanks of Bombay, return to life at the commencement of the "rains," after having been exposed above water for several months to the scorching heat of a tropical sun. The body-substance of a dried *Geodia*, which I picked up on the southern shores of Arabia, manifested polymorphism on being moistened with water several months afterwards. But all who are acquainted with the habits of the Infusoria &c. are familiar with this phenomenon.

It should also be remembered that the sarcode and all its *soft* contents when living are more or less polymorphic, and that therefore at one time they may present one form, and at another another.

Thus the spongozoon among the rest, when observed immediately after the *Grantia compressa* has been torn to pieces for microscopical examination, resembles that above delineated; but after a short interval it may be seen to be moving about the field in the form of an *Amœba*, as before noticed, and with or without the cilium, thus totally unlike the original form.

Indeed this power of polymorphism may enable the spongozoon to assume so many phases that it would be absurd to attempt to describe them all; but when the observer knows that they are the result of a polymorphic property, he will not be surprised at seeing them differ entirely from the shape which the spongozoon presents in the active living sponge *in situ* or, at all events, immediately after it has been eliminated for observation under the microscope by tearing a portion of the *Grantia compressa* to pieces for this purpose.

The spongozoon has its analogue, if not its identity, in the solitary Infusoria, both marine and freshwater, first pointed out and described by the late Professor James-Clark in America (Mem. Bost. Soc. Nat. Hist. 1866, vol. i. pt. 3, pls. 9 & 10; reprinted in the 'Annals,' 1868, vol. i. p. 133); in one specimen of which, viz. *Codosiga pulcherrima* (figs. 23 & 24 *h*), the "reproductive organ" is indicated—equal to our "nucleus."

Development of the Ampullaceous Sac and Spongozoa.

See 'Annals,' 1857, vol. xx. p. 26 &c., pl. i., and 1874, vol. xiv. p. 400, pls. xx., xxi., & xxii. figs. 2, 23, for descriptions and illustrations respectively.

Ovum.

For a description and development of the Ovum, see 'Annals,' 1874, vol. xiv. pp. 321–389, pls. xx., xxi., & xxii.

Spermatozoa.

See 'Annals,' 1874, vol. viv. p. 105, pl. x.

Not being satisfied with my search after the spermatozoa of sponges, I began earlier this year (1875) to examine *Grantia compressa*, with the following results:—

On the 29th of April, 1875. Gathered some branches of *Ptilota* bearing *Grantia compressa*, placed them in sea-water on the spot, brought them home, and in three hours after gathering examined fragments of six, good, large living specimens successively, torn to pieces in sea-water, and placed under $\frac{1}{4}$-inch focus with high ocular. Ova generally about 3-6000ths of an inch in diameter (that is, a little less than double the size of the spongozoon), actively polymorphic, and all the parts visible and well-marked but the germinal vesicle. No appearance of spermatozoa either in cells, free, or about the ova.

On the 5th of May, 1875. The same. Ova generally now about 7-6000ths of an inch in diameter, and all parts, including the germinal vesicle, well defined. No appearance of spermatozoa.

On the 12th of May last year (1874). The same. Ova about 7-6000ths of an inch in diameter, passing and having passed in many instances into the embryonic state (*Gastrula*, Häckel). No appearance of spermatozoa. Living and active specimens of this gathering were also examined on the 13th, 14th, and 15th respectively, with the same results.

On the 16th of May, 1874. The same, but with more embryos. No appearance of spermatozoa. Living and active specimens of this gathering were also examined on the 17th, with the same results.

On the 18th of May 1874. The same in every respect. Living and active specimens of the same gathering were examined on the 20th, when the spermatic-looking bodies, loose and apparently dead (figured in plate x. fig. 21 *l. c.*), were observed.

On the 25th of May 1874. The same in every respect, with the exception of more embryos and fewer ova, but no spermatozoa.

So far, therefore, as my own observations are concerned, I cannot say with certainty that I have yet seen the spermatozoa of any sponge.

The little calcareous sponge *Grantia compressa* has been chosen for examination, from the following circumstances, viz.:—that it is very hardy, grows on branches of *Ptilota* midway between high and low-water marks, may therefore be obtained twice a day and thus gathered without injury; while its breeding-season is now determined; hence, perhaps, where it abounds, it furnishes the best sponge for discovering the spermatozoa.

Epitomism of the Ampullaceous Sac.

Thus, then, the "ampullaceous sac" is an epitome of the whole sponge, in so far as it has an inhalant and an exhalant aperture, and contains the spongozoon or animal of the sponge in plurality, which again has *its* oral and anal apertures respectively, together probably with all the other organs in its body, capable of nourishment and reproduction.

Pore-System and Dermal Cavities.

The pore-system may be divided into the "pores" on the surface, and the "subdermal cavities" with which they are immediately connected; while each division, being equally important, will be separately described.

Pores.

The pores are situated, as before stated, in the sarcode covering the interstices of the dermis, which sarcode is not a homogeneous substance, but composed of a number of polymorphic nucleated cells or bodies of a particular kind ('Annals,' 1857, vol. xx. p. 24, pl. i. figs. 6 & 7; *ib.* 1874, vol. xiv. p. 336). These cells, together with the intercellular sarcode which unites them into a common membranous expansion, have the power of separating from each other, so as to extemporize circular holes or pores, and close them wherever and whenever it may be requisite. The average size of a pore is about 1-100th inch in diameter.

It may open inwardly into a minute canal or into a "subdermal cavity." When the former is the case, the canal in some instances, as before noticed ('Annals,' *l. c.*), goes direct to the subjacent ampullaceous sac; but as the latter are much more numerous than the pores and for the most part deeply situated throughout the structure of the sponge, it may be assumed that the original pore-canal sends off branches to supply them respectively. On the other hand, when the pore opens into the subdermal cavity, it may do so singly or in variable plurality.

In some instances the pores are not generally distributed over the surface, but chiefly limited to certain cribriform areæ, each of which forms the summit of a prominent pustular eminence. These eminences, although separated from each other, are plentifully scattered over the surface of the sponge; and while the pores are open and in active operation the pore-area thus formed presents an expanded convexity, but when they are closed it is conical, puckered, and contracted.

In some instances, again, the dermal layer, together with the subjacent sponge-structure, is prolonged into mastoid (teat-like) or tubular appendages, which thus not only increase the extent of the pore-areæ, but specialize it, so as to indicate that these parts in particular are appropriated to the inhalant function.

Subdermal Cavities.

In 1857 ('Annals,' vol. xx. p. 25), in my account of the development of *Spongilla* from the seed-like body, the "subdermal cavities," as they are more or less united together, have been termed the "cavity of the investing membrane" (*l. c.* pl. i. fig. 1, *b b b*). In 1864 Dr. Bowerbank directed attention to this structure under the term of "intermarginal cavities" (B. S. vol. i. p. 100).

The subdermal cavities are situated immediately under the pores, which thus open into them; and presenting a much more open or cavernous structure generally than that which lies inside them, they are easily recognized in a section of the sponge perpendicular to the surface, where they at once point out the side on which the pores are chiefly situated, in contradistinction to the opposite or vent-bearing surface, whose margin is comparatively without them.

The subdermal cavity has an hourglass-shape, in some sponges at least; and the constricted portion is furnished with a sphinctral diaphragm of sarcode which still further divides them into two chambers, viz. an outer one, which is immediately under the pores, and an inner one, which is extended canal-like into the sponge. (For illustrations of this in *Pachymatisma Johnstonia*, Bk., see 'Annals,' 1869, vol. iv. p. 12 &c., pl. ii. figs. 9–12.)

Being an essential part of the pore or inhalant system, they of course exist in all sponges, although perhaps most strongly marked in the siliceous ones; while the dermal sarcode which covers them, having, as before stated, the property of opening or closing its pores, can by this sphinctral power convert the subdermal cavities into closed or open chambers as required, to say nothing of the more powerful sphincter of the hourglass constriction of the cavity itself, which may act in unison with the pores, or as a check upon them when they admit material that ought to have been rejected.

How these cavities terminate inwardly—that is, whether, after branching out, their radicles are directly, or indirectly through the medium of the ampullaceous sacs, connected with those of the excretory canal-system (to be presently described), or whether some terminate one way and some the other—remains to be shown. (See a description and figure of the subdermal cavity, 'Annals,' 1869, vol. iv. pl. vii. figs. 15, 6 & 9.) As the sponge increases by additional layers to its surface, new subdermal cavities must be continually formed, as the old ones become obliterated by passing into the more compact areolar structure of the interior.

Excretory Canal-System and Vents.

The excretory canal-system commences in radicles among the ampullaceous sacs, which radicles pervade the body of the sponge and, uniting with each other plexus-like, form branches that finally terminate in a large trunk, which opens on its surface in what has been called the "vent" or "osculum," which varies in size, but for the most part is large and conspicuous. In what way the ends of the radicles communicate with ampullaceous sacs in the siliceous sponges has not been satisfactorily explained; but from their opening out of these sacs so directly and conspicuously in the calcareous sponges, it may be inferred that this is the case also in the siliceous ones. Be this as it may, the function of the system is to carry off the excrementitious matter of the sponge, as may be observed in the young *Spongilla* (which at first has only one canal-system, and therefore only one vent) after it has been fed with carmine or indigo.

The opening in which the main trunk of the canal-system terminates may be on a level with the surface, or more or less raised above it by a mammiform (nipple-like) or tubular prolongation of the dermal structure entire, or of sarcode alone; but whether of dermal structure generally or the sarcode alone, the opening is always provided with a sphincter, which may be closed or opened as required. This is similarly situated in some sponges to the sphincter of the subdermal cavity of the pore-system (that is, a little below the surface), but differs from the latter, of course, in not being covered by the poriferous sarcode of the dermis. Where the prolonged vent consists of sarcode alone, the opening of course is at its extremity.

Occasionally the vents appear in little groups, distinctly although irregularly disposed; sometimes they are arranged in a petaloid form, and sometimes stelliformly—that is, with little gutters running to them radiatingly, in the dried state, which are converted into canals by the dermal sarcode during life.

They are situated on the inner aspect of the excavated or tubular sponges, and always on the depending or inner side of flabellated expanded forms, which, on becoming frondose and sinuously plicated, cause the depending sides to vary with the sinuosities—so that the vents are found in patches, sometimes on one, sometimes on the other side, as determined by the undulation of the frondose expansion.

Sometimes the opening of the vent is accompanied by a row of spicules, arranged round the orifice so as to lean towards each other in a conical form when the opening is closed, and *vice versâ* when it is dilated.

Although the excretory canal-system is single in the embryonal sponge, it becomes multiplied as the latter increases in size; so that the surface of a large sponge may present several vents, each of which is generally the outlet of a distinct system or plexus; while the vents may exist here and there singly and separate or in groups, where their size and number indicate those of the system with which they are respectively connected. Moreover the sponge has the power of opening them at one place and closing them at another; while in abnormal states their currents may even be reversed. The notion that each vent represents one "person" or individual sponge is not always correct, as I have shown in the young *Spongilla*, wherein a second vent is occasionally produced, thus forming two for its excretory canal-system ('Annals,' 1857, vol. xx. p. 31). Among the calcareous sponges, too, *Grantia compressa* may have one, two, three, or more vents to its cloacal cavity &c. One vent therefore does not always represent one "person."

Function of the Pore- and Vent-Systems respectively.

As the function of the pore-system is to admit nourishment to the interior of the sponge, so that of the vent- or excretory canal-system is to carry off the refuse. Hence in sponges growing horizontally, like the fungus *Polyporus*, the pores are generally on the upper and the vents on the lower surface; but when sponges grow (as they usually do) on the under surface of rocks, the mammiform or tubular prolongations are directed downwards and terminated by the vents. Where the sponges are tubular, as before stated, the vents open on the inner side of the tube, which has thence been called by Dr. Bowerbank the "cloaca." But whether the sponge be tubular, and thus provided with one great cloacal opening, or whether flat and provided with several, each kind of vent is but the termination of a cavity into which many minor vents have previously opened; so that the great cloacal or general vent is but a modification of the smaller and much more common kind.

For a detailed description of the function of the pores and vents, under the appellations of "afferent" and "efferent canals," see my account and illustrations of the development of *Spongilla* from the seed-like body, 'Annals,' 1857 (vol. xx. p. 27 *et seq.*). But a special study of every thing connected with the pore- and vent-systems respectively throughout the Spongida is much to be desired; for there is yet much to be revealed concerning their functions.

Flesh-Spicules.

As there is a class of spicules entirely connected with the skeleton, so there is one as exclusively connected with the sarcode of the sponge; hence the latter has been called "flesh-" in contradistinction to the "skeleton-spicule." They are objects for the most part of singular beauty, from their often complicated and symmetrical forms, of infinite variety, of microscopic minuteness, and dispersed, without any appreciable regularity or constant quantity, more or less abundantly throughout the sarcode. One or more forms may exist in the same sponge, and thus they become of much importance in specific distinction; but as they do not exist in all sponges, this advantage is not general; while their extreme minuteness, causing them to fall through the skeleton when the sarcode in which they are imbedded putrefies and becomes washed out, as small pebbles pass through the meshes of a large net, still further deprives us, as before stated, of their specific aid in most of the sponges, which never come to hand in any other form than the skeleton.

Where they are present, they may be of use in giving greater firmness to the sarcode—that is, by acting as a kind of sub-skeleton; hence Dr. Bowerbank has called them "retentive spicules:" but as they are frequently absent, and, indeed, the skeleton-spicules, too, in some sponges, the latter can evidently do without them, so we must look for some other bond of union for the sarcode; and this, which may be found in the contractile power that it possesses during life, but which immediately disappears on death, is well exemplified in the calcareous sponges, as before stated, where these, the tenderest of all sponges when dry, grow upon rocks in the midst of the boiling surf during their lifetime.

To describe the forms of these beautiful little flesh-spicules in detail, in a general introduction to the classification of the Spongida, would be out of place; and therefore the student must seek for this in the description of the sponges respectively to which they belong, while now they can be only noticed in a general way; and as with the "skeleton-spicules," so here, it seems best to give a Table of the commonest known forms which the flesh-spicule may assume, that the student may to a certain extent become acquainted with them, and thus prepared to describe others which he may afterwards discover. Descriptions, however, at best are very inadequate to the purpose; and therefore I hope to add hereafter tabular delineations of both the skeleton- and the flesh-spicules, as before stated.

Table of known Forms which may be assumed by the Flesh-Spicule of the Sponge.

I. Linear Group.

Acerate.

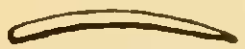
Simple.

Fusiform | Cylindrical curved or straight.

Extremities pointed finely or abruptly; obtuse or round.

Inflated in the centre or towards the ends.

Acuate.



Simple or Fusiform.

Capitate or pin-like.

Smooth or spined.

Bihamate C- or S-shaped, subspiral.

Simple.

Fusiform | Cylindrical more or less spiral or tortuous.

Inflated or not in the centre.

Extremities pointed or obtuse.

Smooth or spined.

Spines partial, general, terminal, or verticillate.

Tricurvate or Bow-shaped.

Simple.

Fusiform | Cylindrical

Curves deep or shallow, varying from nearly straight to pincers-shape.

Equal or inequal.

Extremities pointed, obtuse, or inflated.

Smooth or spined.

Spines general, partial, terminal, or verticillate.

Sinuous subspiral.

Simple.

Fusiform | Cylindrical

Curve single or in plurality, often varying in number with the length.

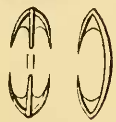
Equal or unequal.

Extremities finely pointed or obtuse.

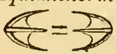
Smooth or spined.

Spines general, partial, terminal, or spiral.

II. Hamular Group*.



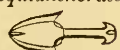
Equianchorate.



Equiended.

Ends conical, expanded alæform, or navicular shuttle-like.

Inequianchorate.



Inequiended.

Ends conical, expanded alate, or navicular.

Ends three- or more armed, *i. e.* fluked.

Arms linear and round; compressed laterally or knife-shaped, with the edge towards the shaft; or expanded alæform, with the central one petaloid.

Shafts of Anchorates.

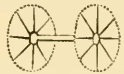
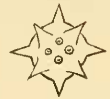
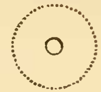
Simple fusiform.

Slightly curved or straight, or tricurvate, *i. e.* bow-shaped (*angulate*, Bk.).

Fusiform, round, or flattened; expanded centrally or throughout.

More or less falciferous—that is, united to the shaft by an arched web-like expansion. Separate or webbed together umbrella-like. Opposite or lateral—that is, on one side only. Disunited, or united end to end with those of the opposite extremity.	Pointed or flattened, expanded or round at the extremities. Alate towards both or one end only.

III. Stellar Group.

Stellate.	*Bistellate, Birotulate or Amphidisk*†.	*Globostellate.*	*Globular.*
			
Radii few or numerous. Opposite or inopposite. Equal or unequal in size and length. Pointed, inflated, or bifid at the extremities. Spined partially, generally, or terminally. Spines vertical or inclined one way or the other.	Ends stelliform (bistellate) or discoid (birotular). Rays stelliform, or rotular and discoid, or recurved and anchorate. Rotula horizontal and irregularly dentate, or discoid with even margin, or discoid with recurved and uniformly denticulated margin. *Umbonate.* Ends equal or unequal. *Shaft.* Straight cylindrical. Smooth or spined. Spines scattered, vertical, irregular in length and position.	Globe or body variable in size. Rays few or numerous; general, or sexradiate and opposite. Pointed, inflated or bifid at the extremities. Smooth or spined. Spines partial, general, or terminal.	Spheroid, ellipsoid; or compressed vertically to extreme thinness (*i. e.* discoid). Structure radiate, compact. Radii simple or branched. Terminating on the surface in stellate, flattened, or inflated or round extremity.

* For a detailed description of the *equianchorate*, see 'Annals,' 1874, vol. xiv. p. 208, pl. xiii. fig. 1, and for the *inequianchorate*, ib. 1871, vol. vii. p. 277, pl. xvii. figs. 7 & 8, both of which must be studied before this Table can be understood.

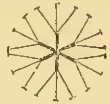
† For figures of the birotulate in the freshwater sponges, see Dr. Bowerbank's 'British Sponges,' vol. i. pls. 210–227.

IV. Hexactinellid Group.

Simple or unrayed.

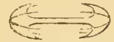
Two- or six-armed.
Arms equal, opposite.
Pointed, inflated, or hooked capitately at the extremities.

Compound or rayed.



Rays double, few or numerous, equal, opposite, and symmetrical.
Straight, sigmoid, or floriform, *fleur-de-lis*-like.
Single or branched.
Smooth or spined.
Pointed or capitate.

Birotular anchorate.*

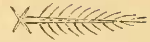


Ends eight-armed, symmetrical, recurved elliptically.
Round or flat at the apex.
Blades or arms knife-shaped, falcate, with the thin end towards the shaft.

Shaft.

Straight, cylindrical, spino-tubercled, especially about the centre.

Plumose.



Ends crucial, four-armed.
Arms opposite, straight, or sigmoid, horizontal or advanced, smooth or spined, pointed or obtuse.

Shaft.

Straight, conico-linear, more or less spined all round plumosely.
Spines long, curved, more or less deflected from the shaft, inclined towards the free end.

Scopiform Flesh-Spicule†.

Head.

Two, four, five, or more prongs. Prongs round, attenuated, smooth or microspined.
Capitate or pointed.
Extended separately *en fleur-de-lis*; or more or less parallelly fork-like.
Or more or less united horizontally, discoid or umbrella-like; recurved. Umbonate.
Rays microspined.

Shaft.

Smooth or microspined.
Pointed at the free end; inflated, just before its union with the head, elliptically and smooth, or presenting four tubercles opposite.

* For figures of these three forms, see 'Annals,' 1873, vol. xii. pl. 13; and for figures of the "Spinicruces" of Brandt, which are peculiar to the lower end of the sponge and corium of the glass rope in *Hyalonema*, see Dr. Bowerbank's 'Brit. Spong.' vol. i. pl. vi. figs. 153–157.

† For figures of these, see 'Annals,' 1873, vol. xii. pl. xv. figs. 1–4.

Observations.

It is not intended that this Table should be considered complete even for all the known forms of the flesh-spicule; but it may aid the memory in retaining an acquaintance with most of them; and as with the Table before given of the "known forms" that may be assumed by the skeleton-spicule, so here, also, this may aid the student in describing new ones of the flesh-spicule.

Specific Value of the Flesh-Spicule.

A few remarks here are necessary as regards the specific value of the flesh-spicule, since, as the same form of skeleton-spicule is often found among the normal spicule-complement of different species of the Spongida, or with such slight and almost inappreciable differences that they are of no use specifically, so it is with the flesh-spicule.

Although the navicular or shuttle form of the equianchorate and the simple minute bihamate are common to several very different kinds of sponges, there is no form so common or so diversified, perhaps, as the tricurvate or bow-shaped spicule, which in many instances is a simple minute acerate so like the skeleton-spicule that it might be easily mistaken for a young form of the latter.

It is under this form that the tricurvate often appears in sheaf-shaped bundles, each bundle of which is developed in a separate cell (see "Mother Cell of the Spicule," 'Annals,' 1874, vol. xiv. p. 100, pl. x. figs. 3–9), and so numerous in some instances that it would appear to afford a characteristic feature, if it did not so happen that the sheaf-shaped bundle is common to so many totally different kinds of sponges. It is therefore desirable to remember that this is the tricurvate spicule which, after the bundles have been eliminated from the mother cell into the structure of the sponge generally, may attain a somewhat more recognizably tricurvate form.

It is also desirable to notice that sponges are often densely charged with minute transparent globules, which have such a siliceous aspect that, if it were not known that the Hyphomycetous Fungi (*Mucor* and *Botrytis*) sooner or later destroy the whole of the sarcode, or soft parts of the sponge, under the least humidity, and thus fill it with their sporules, these little transparent bodies might be taken for a part of the spicule-complement of the sponge. If, however, there should be any doubt on the subject, and the parent filaments or mycelium of the *fungus* be not observed, the doubt may be got rid of by boiling a bit of the sponge in nitric acid, or exposing it to a red heat, which will destroy every thing but the siliceous elements of the sponge.

Muscular Cells.

In many sponges, especially in the harder and tougher species, chiefly about the dermal layer, there are long fusiform cells, whose central contents are a nucleus and several granules. These cells are often united together longitudinally, in the form of a cord, to form the dermal reticulation, or are massed together so as to form a densely tough, contractile cortical layer. Their shape contrasts strongly with the globular cells in the dermis, as may be seen by my figures ('Annals,' 1872, vol. x. p. 107, pl. vii. figs. 10 & 11); while they so closely agree in shape &c. with the fusiform cells of "unstriated muscle," that I have provisionally called them "muscular." I have not been able to make an extended examination of them; but having often met with them in various sponges and in different parts of the sponge, especially in the Pachytragia, it is to be hoped that some one will give his attention to the subject specially, for their general elucidation, as well as that of many other cells of the sarcode whose specific forms and functions have yet to be particularly described and determined.

Colour of Sponges.

The most prevalent colours of sponges are different shades of tawny yellow and brown; but they may be snow-white or jet-black, golden or bright yellow, scarlet or crimson, green, blue, violet, carmine, and purple, passing into the dark neutral tint of writing-ink—indeed, all the colours of the rainbow.

Still the prevailing colour of the horny skeleton-fibre is tawny yellow, brown, or grey; but this is no indication of the original colour of the sponge when invested with its natural sarcode, since in fresh specimens of the officinal sponge the surface most exposed to the light may be black, that less exposed (viz. the sides) purple, and the lower part, which is excluded from the light, almost colourless, or partaking only of the light tawny yellow tint of the interior of the body—a tint derived from the horny skeleton, which, being the only part retained in the officinal sponge, presents the well-known "sponge-colour."

Thus, in this instance, the colour is confined to the dermal sarcode, and is most intense where most exposed to the light, becoming less so in the lower parts; this is the case in all sponges, whether the colour be continued into the sarcode of the body or confined to the surface.

The colouring-matter may be diffused through the sarcode like a dye, or in small pigmental granules; the granules may be diffused generally, or confined in pigment-cells, or both, as if the former had been derived from the latter. Or the colouring-matter may be confined to the spongozoa, which, again, may only partake of it where most exposed to the light, or possess it generally throughout the body. Lastly, the ova on approaching the embryonal state may become coloured; and, in most instances, where the spongozoa and the ova are coloured they present an intensified tint of the sponge to which they belong; so that in a red- or yellow-coloured sponge the ova, when advanced in development, may be recognized generally by being intensely red or yellow, as the case may be. Yet in some cases they appear in the midst of a tawny-yellow-coloured sponge as opaque *white* bodies when they attain their embryonal state (see 'Annals,' 1874, vol. xiv. p. 331).

The same species of sponge may assume different colours; thus *Grantia clathrus*, Sdt. (= *Clathrina*, Gray), may in some instances be vermilion-red, in others sulphur-yellow, and in others grey-white, which is the most usual: here the colour is general, and seated in the "granules." *Esperia macilenta*, Bk., of our coasts, although generally tawny yellow, is sometimes vermilion-red.

The colour, again, may be "fast" or permanent, or fade after death, and on drying or preservation in spirit disappear altogether, or leave a grey or brown tint only. Again, some calcareous sponges (*Clathrina*) which are opaque white while living, become brick-brown when killed by being thrown into fresh water; while others (*Grantia nivea*) retain their opaque snow-white colour under all circumstances. The cause of this has not been explained.

Then, again, the tawny-yellow colour of the officinal sponge of the shops, which, as before stated, is due to that of the horny skeleton-fibre of which it is alone composed (which fibre is analogous to the fibre of wool or that of the cocoon of a silk-worm), is no indication of the colour of the skeleton-fibre throughout the Spongida; for it may be of all shades, from colourless, grey, to brown, yellow, and deep dark amber; while in one instance at least (*Spongia flabelliformis*, Pallas; *Ianthella*, Gray), where the soft parts are madder-brown and the fibre deep amber, there are layers of carmine-coloured cells intercalated with those of the fibre, thus presenting a beautiful appearance under the microscope.

Lastly, the colour may be due to the presence of a parasite, as in the cerulean sponge of the rocks here (Budleigh-Salterton), which only appears in patches about half as large as the nail of the finger, but always of a sky-blue colour, possessing a pin-like spicule, and accompanied by a minute *Oscillatoria* in the form of short bacillar filaments like those colouring the Red Sea, in whose granules the pigment is seated which gives the blue colour to the sponge while fresh, though the blue fades greatly on drying. The green colour in *Spongilla* also sometimes depends upon the presence of an *Anabina*, but as often comes from its own granules; while *Halichondria incrustans* is often pervaded and rendered pink by a minute alga whose cells, both fresh and dry, present a beautiful red Floridean colour; indeed the mere contact of a red seaweed with a sponge may be followed by the latter assuming a similar tint.

The most striking colour which I have seen among the sponges is the carmine of the Suberites *Alcyonium purpureum*, Lam., from Australia, and *Vioa Johnstonii*, Sdt., from the Adriatic, whose spicules are very much alike, and in both of which the colour is exquisite and permanent.

Starch.

Starch, impalpable, diffuse, or amorphous, and in the common potato form of grains, although much more compressed, is common in *Spongilla* and probably in sponges generally; the latter form is even found in the ovum or seed-like body ('Annals,' 1859, vol. iii. p. 334, pl. i. fig. 7). Still it is very necessary, in examining marine sponges for starch, to be sure that the latter does not come from a neighbouring Fucus, whose cells are always pregnant with starch-grains, and very apt to be cut open when minute and intimately connected with the sponge under microscopical examination.

Size of Sponges.

Some sponges are always diminutive, others only so when they are young. In some places the same species may be only found in small amorphous fragments, while in others it may attain a large size with definite form. The largest size that a sponge may attain under favourable circumstances (that is, unmolested &c.) is almost indefinite; so that the size of a specimen, unless very large or very small and of definite form, goes for nothing specifically.

All the calcareous sponges are small, and many diminutive, even when full-grown; while many species of siliceous ones have been found of very large dimensions. Thus, while the cavity of *Grantia ciliata* may when full-grown only admit a pin's head, a small child might sit down in the great suberitic siliceous sponge called "Neptune's cup." Dr. Bowerbank, in a note written to my friend the late Dr. J. E. Gray, mentions a massive sponge (Suberite, *mihi*) nearly as large as a "military drum;" and the crown of another from Belize, in the Bay of Honduras, "3 feet across." The well-known "Neptune's cup," just mentioned, also belongs to the Suberitida. Mr. Clifton, again, in a note to Dr. Gray (which I possess), states that he has seen specimens of a branched sponge (*Axos Cliftoni*, Gray) on the beach in South Australia, after a storm, "6 feet long." In the British Museum there are many species, too, of totally different sponges, massive, excavated and frondose, or flabelliform, of comparatively gigantic growth; but, as I have before stated, they are only indications of the size that some sponges may attain, and therefore of little or no value specifically. Still the smallest and most amorphous fragment of a sponge which presents a new set of spicules should not be overlooked. That called "*Acarnus innominatus*, Gray," I first found on a large specimen of *Ectyon sparsus*, Gray, from the West Indies, in a fragmentary state not larger than the human nail ('Annals,' 1871, vol. vii. p. 273, pl. xvii. figs. 4–6), a specimen of which as large as the human head was afterwards presented to the British Museum, from Ceylon, by Mr. Holdsworth.

Parasitism.

As no living being is exempt from parasites, so the sponges have theirs. Algæ, polypes, cirripedes, and crustaceans live in and on them respectively, as I hope to show hereafter in a separate and illustrated communication. One parasite in particular, for which I have proposed the name of *Spongiophaga communis* ('Annals,' 1871, vol. viii. p. 330), so entirely replaces and simulates the sarcode of the original sponge, in *Hircinia* especially, that, but for its occurrence in many other sponges of a totally different kind and in different parts of the world, it might (as it has been) be considered part of the sponge itself.

Fossil Sponges.

In a palæontological and geological point of view, it might be assumed that all the orders of sponges to be hereafter mentioned existed as far back, at least, as the Upper Greensand of the Cretaceous system, not only from the resemblance of entire forms, but from actual identification of the spicules and other elementary parts themselves. These, besides being found in the powder of many hollow flints, exist at Haldon Hill, near Exeter, promiscuously and abundantly in a distinct stratum of fine sand—the former in direct connexion with the fossilized sponge, and the latter in a drift-accumulation. This has long been known; and what I have stated respecting the representatives of the orders will be found in the figures &c. of my paper on the subject, published in the 'Annals' of 1871 (vol. vii. p. 112, pls. vii. to x. inclusive). It is true that all the orders are not represented by the bare spicules and fragments of glassy fibre therein illustrated; but sufficient, I think, to justify our assuming that the others, which can only be recognized by a fragment of the entire fibre respectively, may hereafter be found in this very interesting, but very little worked, field of discovery.

What took place in the Cretaceous Period is taking place at the present day, especially in the deep sea, as evidenced by the "dredgings" of H.M.S. 'Porcupine,' which indicate, through the specimens now with me, that about 100 miles north of the Butt of Lewis, in 632 fathoms (station no. 57), there must be a bed of sponge-spicules of many kinds, portions of which are rounded by the currents into pebble-like forms, which one day may become the nuclei of flints or rounded portions of sandstone respectively, like those now scattered over the Cretaceous area; while the bed itself may become, like that in the Upper Greensand of Haldon Hill, a heterogeneous mass of sand and fossil sponge-spicules. So also a recent specimen of the same "dredgings," figured in the 'Annals' (1873, vol. xii. pl. i. figs. 1 & 2), consisting, at least, of *seven* different sponges congregated together in a very small space on a bunch of dead *Lophohelia*, points out how "the powder of hollow flints" is often found to contain a heterogeneous mixture of spicules in addition to those which belonged to the original sponge, and thus defies all attempts, in many instances, to specialize the latter.

[To be continued.]